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## INTRODUCTION

In responding to the Inquiry, Belar wishes to introduce more of the history pertaining to the introduction of FM stereo broadcasting, along with the performance standards and monitoring requirements established by the Commission at that time. Belar believes this history has a direct bearing the discussion of this Inquiry, relating in particular to the definition of modulation and the definition of overmodulation.

When FM Stereo was first introduced, the Commission went through the standard Notice of Inquiry procedures and then issued a Rulemaking. To insure a good quality signal for listeners and guarantee minimum performance standards, a sensible set of rules was established. To insure a "level playing field" for the broadcasters, as part of the Rulemaking the Commission set minimum performance standards for both stereo transmissions and Type Approval of FM stereo monitors. The performance standards included tests to insure the "goodness" of the stereo signal, as well as tests to insure that the monitors were capable of detecting and displaying the peak deviations of the stereo signal. Implicit in the Commission's actions was the assumption that modulation meters themselves "peak weighted" their indications of modulation peaks, in accordance to their ballistic characteristics. At the time, the Commission was not satisfied with the accuracy of meter indications for stereo signals. Thus, standards for peak flashers were tightened to accurately display peak modulation above preset levels. Peak flashers were required to respond to specific tone burst tests modulating the main channel (L+R), the left and right channels separately (L,R), and the stereo difference channel (L-R). It had to respond accurately to all of these, both with and without any SCA signals. In other words, the flashers had to respond to the whole stereo composite signal.

(It should be noted that peak flashers that responded correctly to stereo composite signals necessarily respond to

peaks of very short duration, since the stereo composite signal has frequency components up to 53 kilohertz, and subcarriers contain frequencies up to 100 kilohertz.)

Despite of the standards set for the new stereo monitors, they were essentially simple devices that could be manufactured at reasonable cost.

De-regulation in 1983 removed not only the Type Approval requirement for modulation monitors, but removed the requirement that stations specifically use modulation monitors to verify their modulation. Further de-regulation in 1986 removed most of the FM stereo performance standards. The rule setting minimum stereo separation was reduced to the simple requirement that the stereo subcarrier be modulated by the difference between the left and right channels. The only other stereoperformance regulation remaining intact was the 2 Hz pilot frequency error limit. All the "goodness" standards were removed.

What now remains after de-regulation is Rule 73.1570 specifying maximum and minimum permissible levels of modulation. For some, particularly broadcasters, the most troublesome aspect of this rule is the statement that "modulation must not exceed 100 percent on peaks of frequent recurrence". Broadcasters often rely on technical consultants for appropriate interpretation of this rule.

Much of the current confusion about allowable modulation levels can be attributed to the combined effects of: the elimination of technical standards for the design and use of modulation monitors, the apparent inconsistency between modulation rules for conventional stations and those using automatic transmitter control equipment (ATS), and the subjective nature of the "peaks of frequent recurrence" rule (73.1570). Clarification of the modulation rules is overdue.

Modern processing and transmitting equipment allow the broadcaster to precisely limit modulation peaks to within 2 percent or so. Depending on the equipment and its proper operation, this precision is often obtained at the expense of

signal quality. From Field Office experience we know that FM broadcasters often set their modulation to exceed 100 percent by a margin just less than what they believe will result in a citation. This is done purely for competitive advantage.

The Commission (as indicated in Paragraph 6 of the Inquiry) is aware that use of the "peak weighting" method of indicating modulation peaks would allow broadcasters to attain high levels of modulation without requiring as much compression of the dynamics of program material as would be required to attain high modulation levels under current rules. The unfortunate result of legitimizing this technique would be that many, if not most, broadcasters would use any freedom peak weighting allows them to increase their modulation levels without reducing the amount of compression applied to the program material. The radio listener suffers in three ways:

First, the "flat" quality noted in the Notice of Inquiry will not be reduced for many listeners. Loudness will remain the order of the day on the FM broadcast band--the band that technically permitted us to have noise-free programming with high dynamic range.

The second deleterious effect of officially adopting a peak weighting standard concerns the likelihood of increased adjacent-channel interference for the FM band. The correlation between peak modulation levels and the occupied bandwidth of FM stations has been long noted empirically. The precise relation is difficult to establish, except possibly for long-duration measurements based on assumptions concerning the spectral nature of programming material and the stationarity of this spectral nature over time. In a simplistic, but arguably appropriate assumption of a Gaussian noise characteristic for the program signal modulating an FM broadcast carrier, the RMS bandwidth of the modulated wave (FM signal) is proportional to the RMS frequency deviation (the RMS value of the full-wave rectified

modulation signal amplitude)<sup>1</sup>.

This manufacturer's experience is that use of a commonly used peak weighting value for peak flasher indications results in a decrease of up to about five to eight percent in indicated modulation. With competitive pressures as they exist, we would expect that if peak-weighting comes into force, that most broadcasters would increase their peak modulation by the extra margin the peak-weighting would permit. This would result in increased adjacent channel interference, particularly for stations broadcasting stereo. This problem may actually have become more acute since the introduction of electronically tuned radios, for which high-Q tuning stages are more difficult to obtain.

The third concern about the peak weighting and the inconsistencies that it introduces in modulation levels is the discrepancy that has been noted between the loudness of different stations on the dial. There are two effects that result. Radios designed for present modulation standards have discriminators and IF filter systems designed for a tolerable distortion level based on expectations for peak amplitudes appropriate for the current modulation standard. Increasing the amplitude and duration of peaks exceeding the present design standards would increase the distortion perceived by listeners and in a way would make present receivers "incompatible". This fact is recognized in Paragraph 3 of the Inquiry. Also, variation in modulation levels requires listeners to readjust their listening volume as they tune between stations--a reduction in "interoperability".<sup>2</sup>

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<sup>1</sup> Norman Abramson, "Bandwidth and Spectra of Phase-and-Frequency-Modulated Waves", IEEE Transactions on Communications Systems, December 1963, pp 407--414.

<sup>2</sup> "Interoperability" is one of four categories of desirable regulations delineated in a paper by Robert S. Powers of the FCC titled "Broadcasting Standards and the FCC". It appeared in the IEEE Transactions on Broadcasting, Vol. BC-30, No. 3, September 1984, pp 67--70.

## **RESPONSES TO PARAGRAPHS OF NOTICE OF INQUIRY**

In this section of our comments, Belar will address issues raised in specific paragraphs of the Commission's Notice of Inquiry.

### **Paragraphs 3 & 6**

The design of consumer radios is based on the peak deviation specifications of Rule 73.1570. A compromise is made between distortion and selectivity, according to the quality of the radio. Thus we have the "boom boxes" and personal radios on one end of the scale, and "Hi-Fi" sets on the other. Increasing peak deviation limits would only tend to degrade the quality of service delivered due to deviation limits implicitly designed into present receivers.

Increases in peak deviation limits above that of Rule 73.1570 increases the loudness of the broadcast signal and gives some wealthy broadcasters an unfair advantage until the others are able to install similar monitoring equipment. The expected result for both these situations is a degraded service.

Disregarding peaks of short duration may allow broadcasters to reduce the amount of compression they apply to their programming. However, if compression is not appropriately reduced, the RMS modulation will increase, along with the RMS bandwidth and interference potential of the FM wave (as discussed previously).

We note here that many broadcasters confuse "loudness" with "presence", which is related to the spectral balance of program material and how it is processed. A listener selects the program he listens to primarily on the basis of its content. The listener then adjusts the volume control appropriately. The decision is not made on the basis of loudness (deviation). The supposed advantage of loudness is only a possible benefit during tuning or in extreme fringe areas that are not subject to significant interference. Under most other listening situations, loudness would be considered a liability.

#### Paragraph 8

Belar believes the simplicity, accuracy, and economy of conventional peak flashers warrant their continued use. We infer from the statement, "...circuitry in the newer modulation monitors detects peak deviation levels exceeding a user specified level (usually 100%) and flashes a warning light." that the Commission may be unaware of the simplicity of peak flashers and the fact that they have been in every modulation monitor manufactured in this country for many years. The accuracy of the flasher circuits was increased with the advent of FM stereo monitors, as discussed earlier.

Belar concurs that clarification of the rules concerning modulation levels is required. Additionally, we believe that appropriate techniques for modulation measurement need to be set forth. Changing basic standards for compliance is likely to be complicated and could lead to unpredictable results.

#### Paragraph 10 & 11

We would anticipate much difficulty in determining an appropriate standard for a spectral modulation measurement. The statistical nature of programming material requires that the element of time be a part of any standard. Definitions of allowable occupied spectrum and the precise techniques prescribed for its measurement are likely to be significantly more complex than for peak modulation. Employing an RF spectrum to determine maximum allowable modulation opens the door for even more aggressive spectral alteration of program material to maximize loudness.

General statistical models for occupied bandwidth support the general validity of present peak deviation modulation limits. The FCC would likely be exchanging approximately equivalent measures if it were able to successfully implement limits based on occupied spectrum.

## Paragraphs 16 & 17

The simplicity and economy of current type modulation monitors makes the suggested spectral measurement instruments seem almost foolish. Belar also notes that a spectrum-based modulation limitation presents the question of the amount of out-of-band power that could be tolerated and the duration of any possible excesses. This seems to be exchanging one conundrum for another.

## REGARDING THE INQUIRY

In the following paragraphs, Belar outlines what we believe to be the choices the FCC can reasonably pursue, along with our evaluation of their appropriateness and likely efficacy.

A deliberate consideration of the situation leads one to the conclusion that the Commission has three practical alternatives from which it may choose. They follow:

1. Leave the present modulation standard as outlined in Rule 73.1570 in place. Additional clarification and consistent enforcement are required.
2. Initiate a new Rulemaking procedure removing peak modulation limits and adopting a peak-weighting system in their place.
3. Initiate a new Rulemaking procedure removing peak modulation limits and instituting new emission limitations in their place.

We now discuss the merits of the alternatives.

Maintaining peak frequency deviation limits in the present form of 73.1570 satisfies one of the major objectives of the FCC as described by Robert S. Powers.<sup>3</sup> In his paper he indicated, "A major objective of the Federal Communications Commission is to eliminate unnecessary regulations. By doing so, we expect to create an environment that encourages innovation and avoids unnecessary and costly rulemaking. This in turn we believe will result in faster development of the technical and economic

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<sup>3</sup>Robert S. Powers, op cit.

potential of telecommunications in this country, and for that matter, in the world. The US is at this time still the leader in telecommunications development, although the Japanese and other nations of the world are clearly giving us a run for our money--literally." (An interesting aside to this point is that many nations are adopting old US standards for modulation measurement. This is attested to by Belar's increased sales throughout the world.)

Maintaining 73.1570 provides a definite design standard for receiver manufacturers. In this situation, having a minimum standard for broadcasters is not an impediment to innovation. A reasonable standard should foster innovation. A simple and precise technical standard for modulation serves the convenience of the broadcasters, the manufacturers, the listeners, and the regulators.

Appropriate clarification of 73.1570 would not require an expensive new Rulemaking and would allow broadcasters to continue using their present equipment.

Implementing the second alternative invoking a peak-weighting standard necessitates a costly rulemaking. While equipment complexity and expense would be limited, the expected increase in modulation levels would have deleterious effects. As outline above, larger peak deviations would diminish receiver performance due to inadequate discriminator and IF bandwidth.

Broadcast standards for station spacing and interference have been defined through years of field experience and allocation decisions. Incrementally increasing modulation will aggravate most present adjacent channel interference conditions.

Additional Commission study would be required to determine a peak-weighting algorithm that would minimize additional interference.

The third alternative, implementing a modulation standard based on occupied bandwidth presents the Commission with its most daunting challenge. Extensive staff engineering work and field tests would be required, resulting in a very expensive Rulemaking

procedure. This would not guarantee, however, the predicted or desired interference protection.

If such an emission standard were successfully implemented, we would likely see broadcasters altering the frequency response of their program material in order to maximize their loudness without exceeding the spectrum limitations.

One is tempted to ask whether this alternative makes sense. We are considering setting modulation by measuring emission. If present emissions are acceptable, it seems logical, rather than attempting to increase modulation levels and developing sophisticated new measurement hardware, to stay the course and accept the performance of conventional unweighted peak deviation measurements.

One is tempted to use the adage:

"If it ain't broke, don't fix it."

#### **ILLUSTRATIONS OF EMISSIONS VERSUS PEAK MODULATION AND PEAK-WEIGHTED MODULATION INDICATIONS**

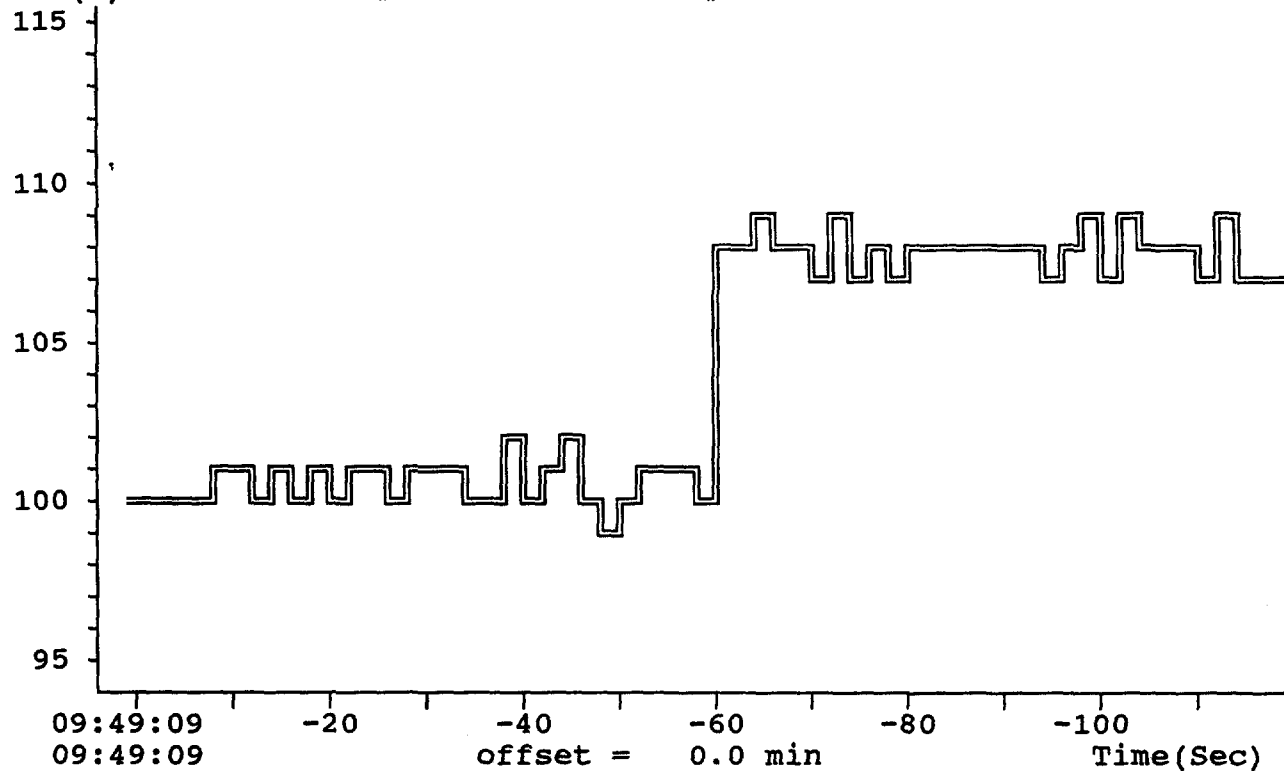
To illustrate one of the major problems of instituting a peak-weighting method for setting modulation, we are including a recording from a Belar FMMA-1 Wizard showing peak modulation levels versus time for an FM station with two subcarriers. We refer to the upper portion of Figure 1. During the first 60 seconds, peak readings are shown for 9 cycles of peak weighting. For the second half, the peak weighting circuit was turned off. The large disparity in modulation indications is evident. For reference, the spectrum photograph of the off-air signal is also shown in Figure 1.

As an experiment to show what the implications of an emission-based modulation Ruling might be, we include Figures 2 through 4. For each of these figures, we derived a modulating signal for a closed-circuit FM station from the L+R component of the station illustrated in Figure 1. To guarantee that the effects of the peak level audio processing of the station of Figure 1 was maintained, the L+R signal was extracted from the

station's composite signal through a digital phase-linear low-pass filter. Figures 2 through 4 show the connection between the peak deviations and the corresponding FM emissions. Figure 2 shows the modulation of the L+R portion of the composite signal for this station. This represents the reference for the next two figures and corresponds to the upper emission plateau of Figure 1.

In Figures 3 and 4 the peak deviations were increased to illustrate the effects likely to result if stations were constrained by an emission limitation for modulation. Above each spectrum photograph is a recording of the peak modulations versus time. The increase with emission level is obvious.

MOD(%):100.1 GAIN#1: 0.0 % GAIN#2: 0.0 % ID:



#### AXIS SCALE

F1-LEFT  
F2-RIGHT  
F3-UP  
F4-DOWN  
F5-EXPAND  
F6-CONTRACT

#### OPTIONS

F7-PAUSE  
F8-RESET  
F9-LOG OFF  
Esc-EXIT  
F10-DATA  
PEAK AVE MIN  
DENSITY

#### LOOP-THRU'S

^F1-#1 UP  
^F2-#1 DN  
^F3-#2 UP  
^F4-#2 DN

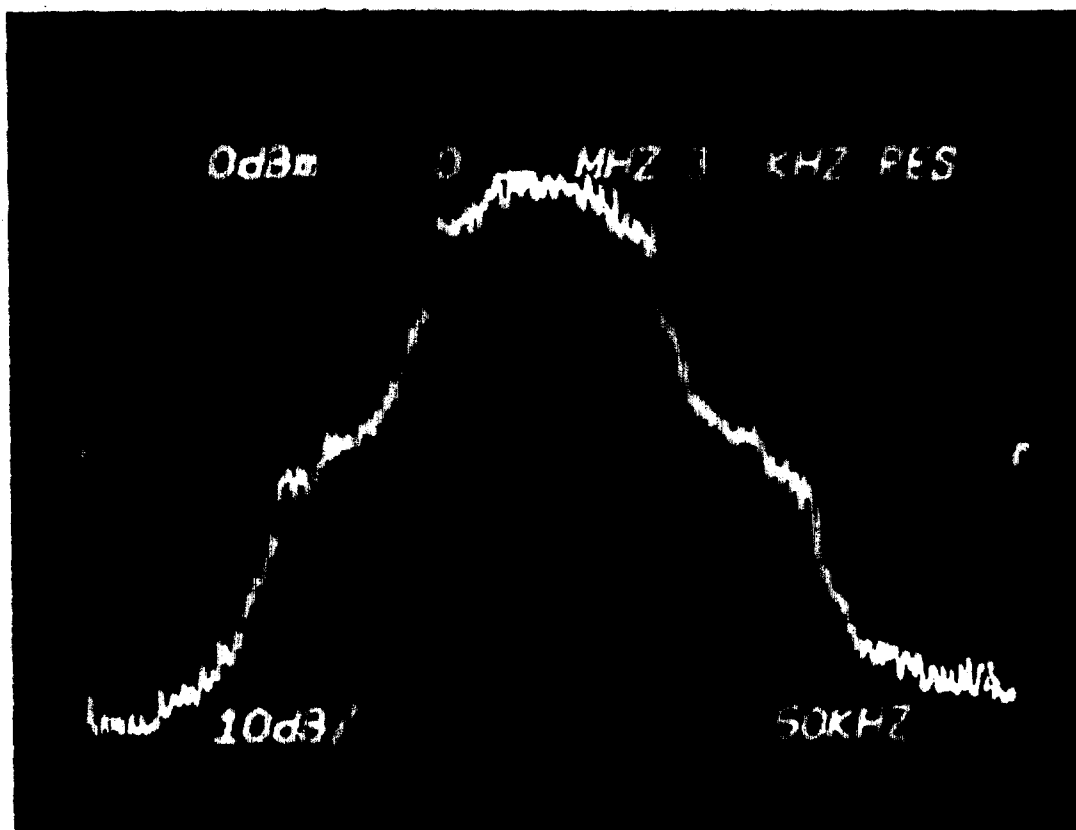
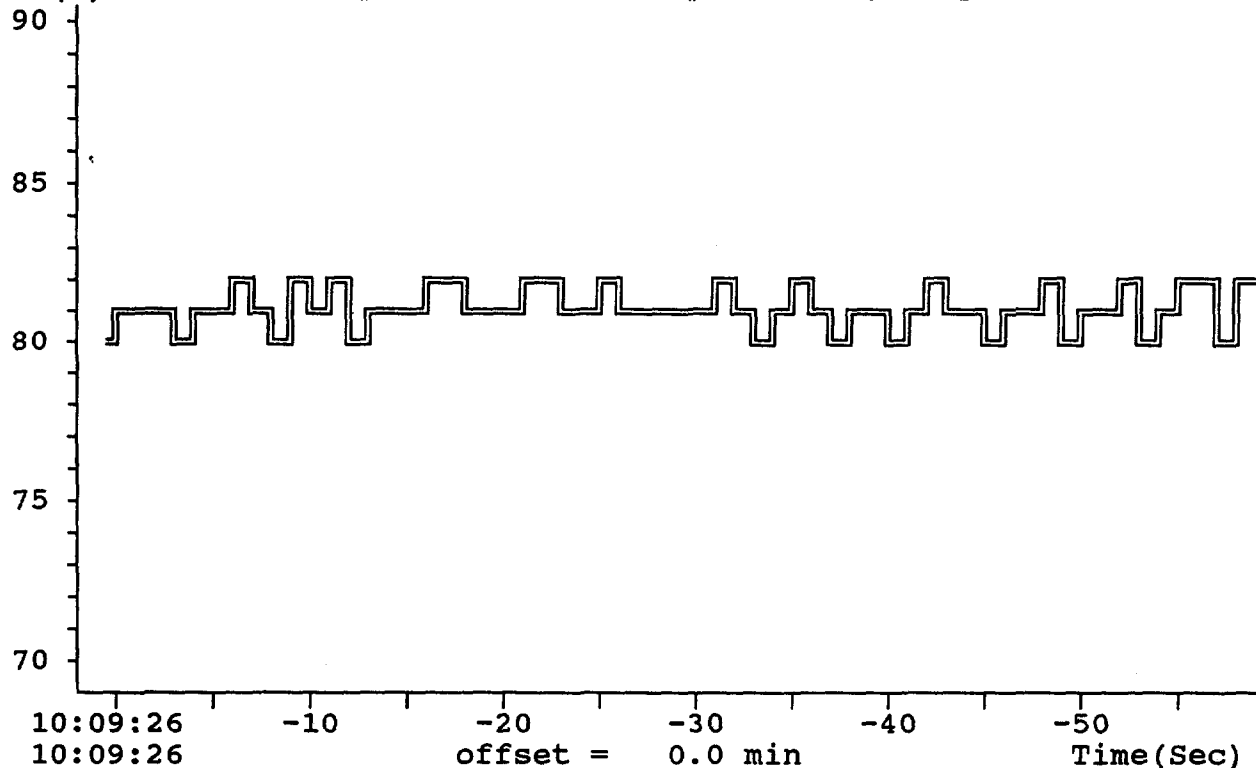


FIGURE 1

MOD(%): 80.4 GAIN#1: 0.0 % GAIN#2: 0.0 % ID:



#### AXIS SCALE

F1-LEFT  
F2-RIGHT  
F3-UP  
F4-DOWN  
F5-EXPAND  
F6-CONTRACT

#### OPTIONS

F7-PAUSE  
F8-RESET  
F9-LOG OFF  
Esc-EXIT  
F10-DATA  
PEAK AVE MIN  
DENSITY

#### LOOP-THRU'S

^F1-#1 UP  
^F2-#1 DN  
^F3-#2 UP  
^F4-#2 DN

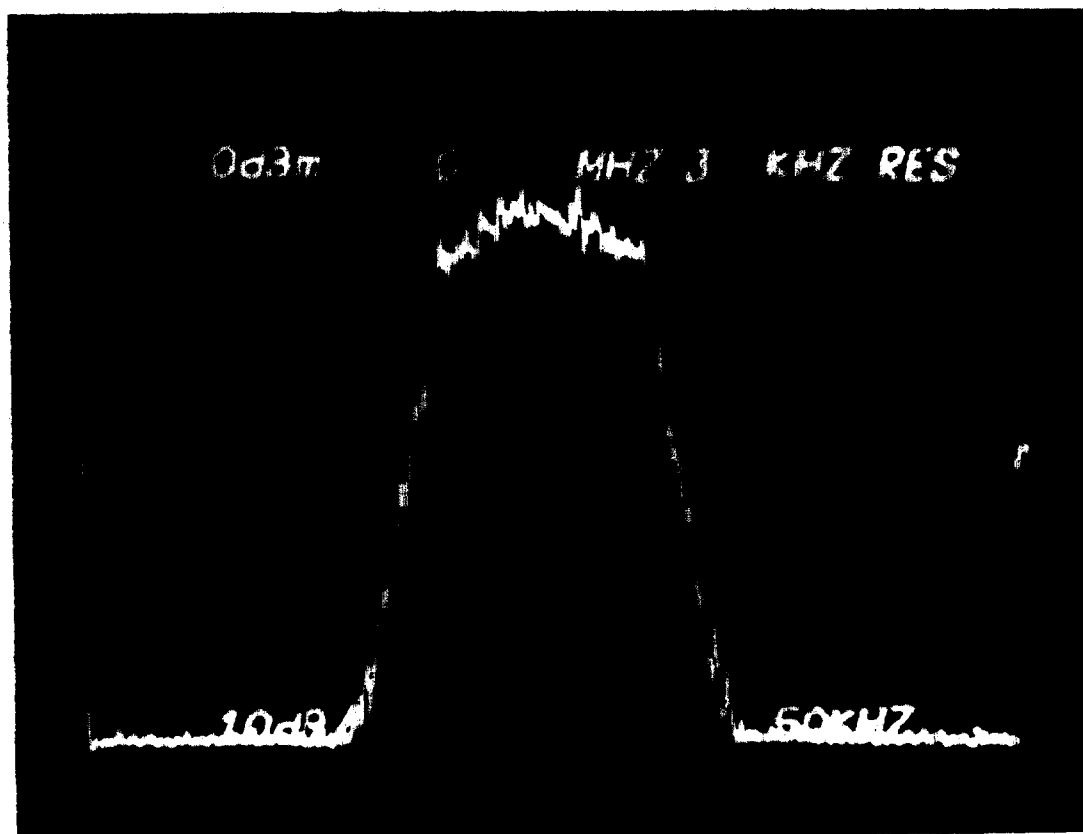
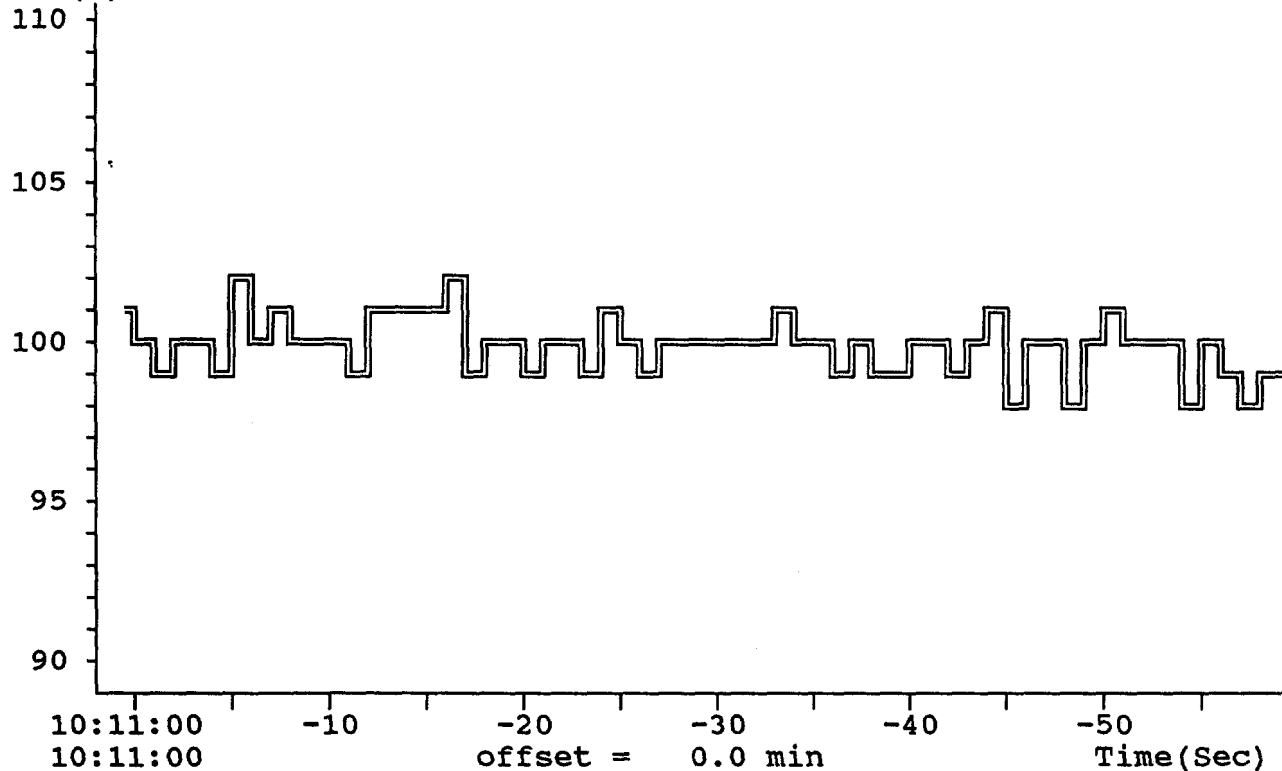


FIGURE 2

MOD(%):100.6 GAIN#1: 0.0 % GAIN#2: 0.0 % ID:



#### AXIS SCALE

F1-LEFT  
F2-RIGHT  
F3-UP  
F4-DOWN  
F5-EXPAND  
F6-CONTRACT

#### OPTIONS

F7-PAUSE  
F8-RESET  
F9-LOG OFF  
Esc-EXIT  
F10-DATA  
PEAK AVE MIN  
DENSITY

#### LOOP-THRU'S

^F1-#1 UP  
^F2-#1 DN  
^F3-#2 UP  
^F4-#2 DN

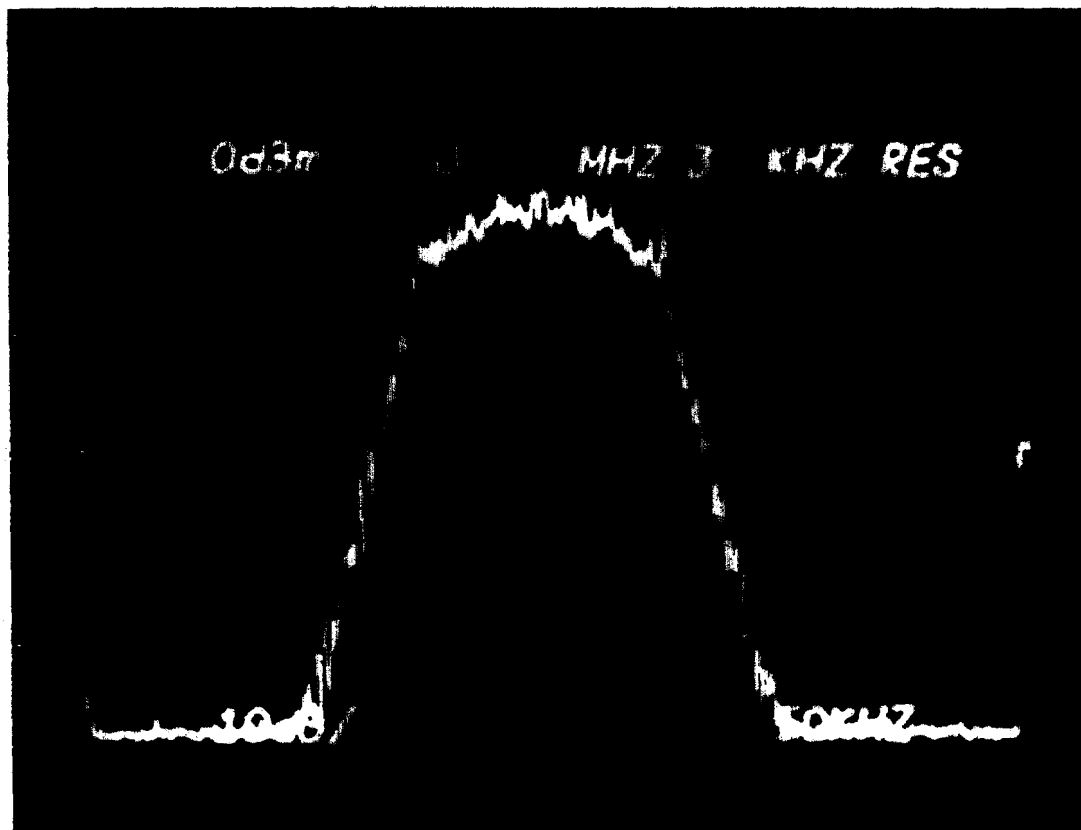
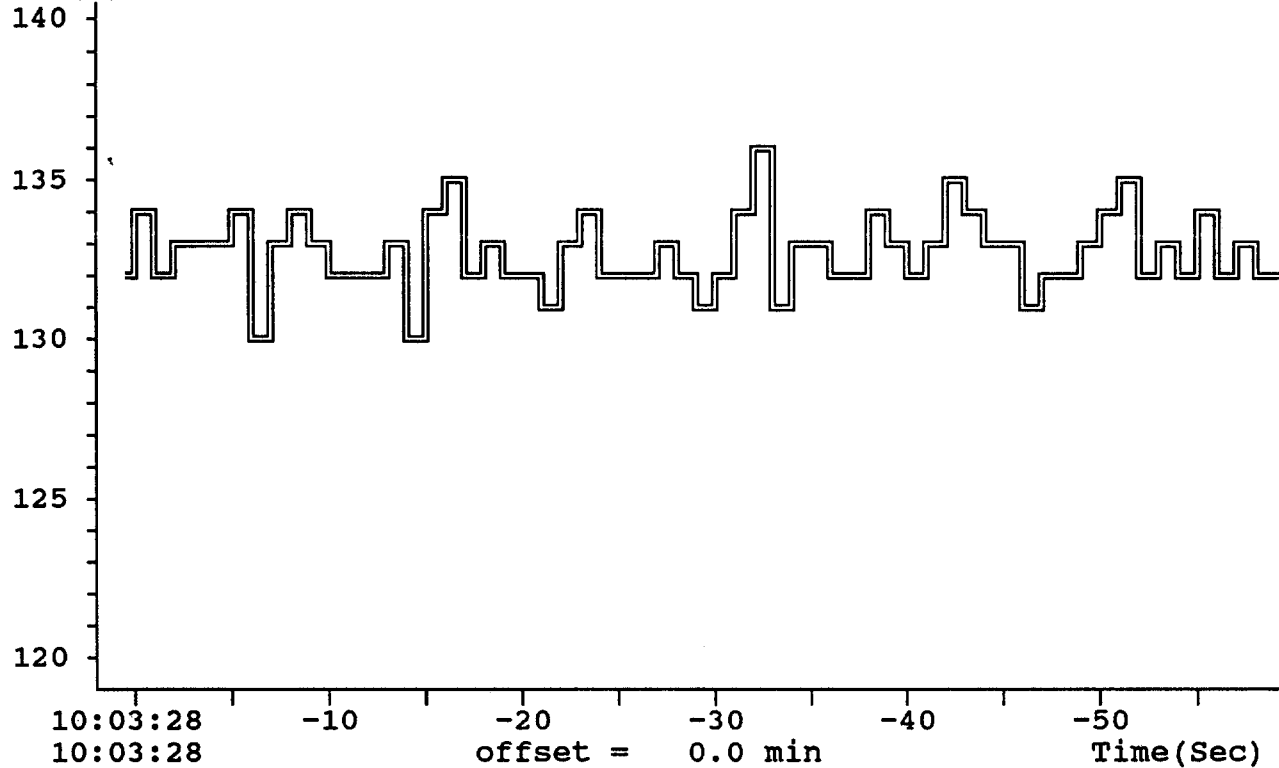


FIGURE 3

MOD(%):132.4 GAIN#1: 0.0 % GAIN#2: 0.0 % ID:



#### AXIS SCALE

F1-LEFT  
F2-RIGHT  
F3-UP  
F4-DOWN  
F5-EXPAND  
F6-CONTRACT

#### OPTIONS

F7-PAUSE  
F8-RESET  
F9-LOG OFF  
Esc-EXIT  
F10-DATA  
PEAK AVE MIN  
DENSITY

#### LOOP-THRU'S

^F1-#1 UP  
^F2-#1 DN  
^F3-#2 UP  
^F4-#2 DN

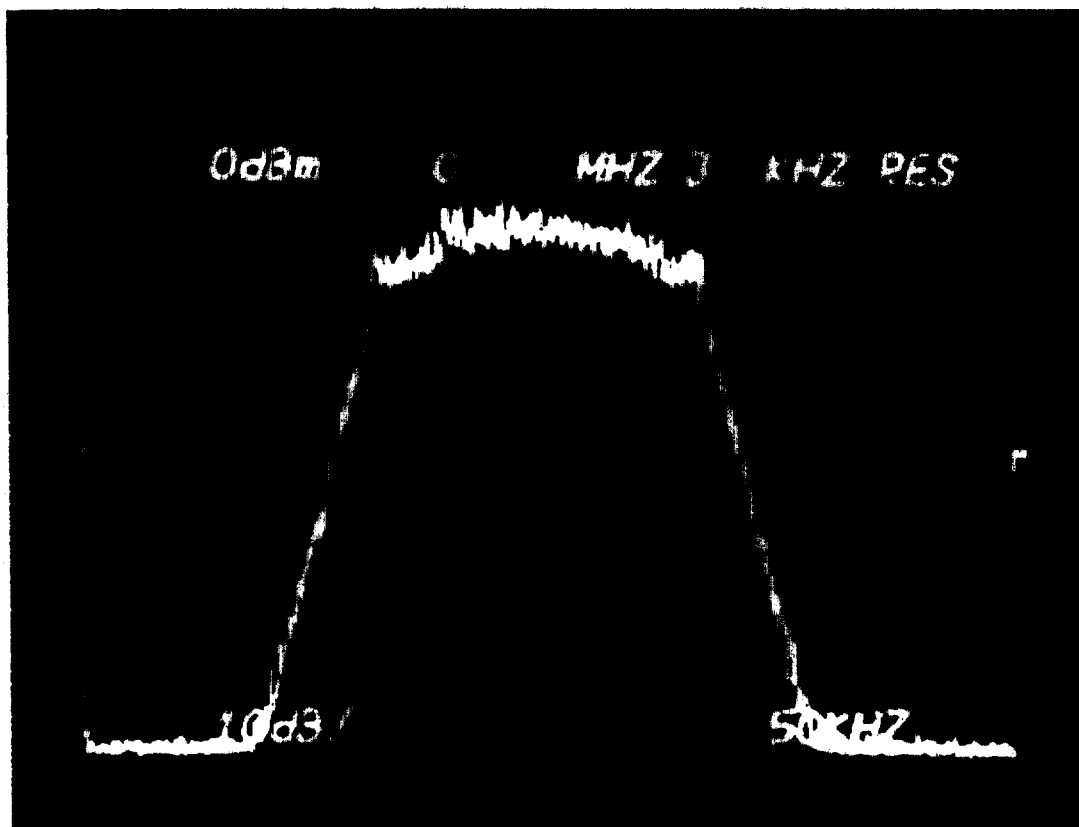
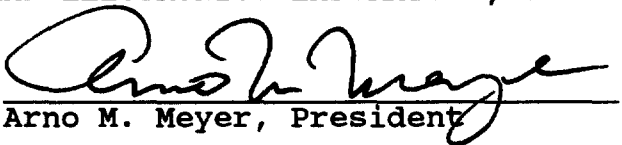


FIGURE 4

Respectfully submitted,  
BELAR ELECTRONICS LABORATORY, INC.

By:   
Arno M. Meyer, President

119 Lancaster Avenue  
P.O. Box 76  
Devon, PA 19333  
(215) 687-5550

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